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REPORT OF ACTIVITIES July-August 1989

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ANTARCTIC ECOSYSTEM RESEARCH GROUP

La Jolla, California

Review of Antarctic Ecosystem Research Plan Completed

On July 11, 1989, the Advisory Panel to the Antarctic Ecosystem Research Group (AERG) was convened to provide advice to the Center Director concerning the direction of research to be completed by the U.S. Antarctic Marine Living Resources (AMLR) Program. The meeting was held at the U.S. State Department in Washington, DC. Members of the Panel included representatives of the State Department, Marine Mammal Commission, Environmental Defense Fund, National Science Foundation, and NOAA Fisheries Headquarters.

Dr. Rennie Holt, AERG Chief, summarized the criteria that were provided by the Panel and used to evaluate three alternative research strategies. All members felt that the proposed research should consider the likely budget level. In addition, they expressed concern that there is insufficient time between the beginning of the fiscal year (October 1) when funding becomes available and the beginning of the field season in late November to complete contracts and obtain equipment and supplies. They suggested that funding should be provided one year in advance.

The members also felt that the research should meet research priorities set by the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR). Research should also be done without duplicating research efforts of other nations and other U.S. research efforts. Finally, tasks for which the U.S. is uniquely qualified (e.g., collection of satellite imagery data) should be given priority.

The Panel reviewed a strategic planning document which presented three research alternatives plus basic "core" research which must be undertaken in conjunction with either of the three alternatives. The proposed research plan was designed to support CCAMLR priorities which include active participation in the Fish Stock Assessment, Ecosystem Monitoring, and Krill Working Groups. AMLR field research activities will focus on the Antarctic Peninsula which has been designated by CCAMLR as an area for concentrated integrated studies. This area is important to commercial fisheries, is home to a high abundance of protected species, and offers the advantage of complementing other national and U.S. marine research efforts.

Based upon recommendations of the Advisory Panel, the AMLR research will consist of offshore sampling of prey and environmental conditions, coupled with land-based studies of predators during the austral summer to investigate factors influencing the reproduction, growth, survival, abundance, and distribution of key biotic components of the marine ecosystem. The research will be conducted in the vicinity of Elephant Island, South Shetland Islands. It will examine both intra- and inter-annual natural variability on a long-term basis to assess the potential impact of human activities. A 10-year time series of measurements is crucial to understanding the nature of this variability.

Specific research tasks will include systematic ship surveys and monitoring at coupled offshore and land-based sites, development of reliable survey methods for interpreting the results of monitoring activities, investigation of methods to better determine krill abundance and distribution, determining spatial and temporal scales of krill aggregations, and analyzing remote sensing data obtained via satellite to investigate broad patterns in environmental conditions within the study area during both the austral summer sampling period and winter season in conjunction with satellite monitoring of crabeater seals.

Based upon this plan, a preliminary cruise announcement and a solicitation of proposals were distributed in July 1989. The deadline for receiving the proposals was September 15, 1989. A finalized research plan will then be completed. (R. Holt, FTS 893-7601)

Meeting Held of the Working Group for the CCAMLR Ecosystem Monitoring Program

The fourth meeting of the Working Group for the CCAMLR Ecosystem Monitoring Program

(CEMP) was held August 23-30 in Mar Del Plata, Argentina. The U.S. delegation consisted of Drs. Rennie Holt, John Bengtson of the National Marine Mammal Laboratory, and Polly Penhale of the National Science Foundation. Other national delegations were from Argentina, Australia, Brazil, Chile, India, and the United Kingdom.

Major agenda items considered included 1) evaluation of agreed predator monitoring parameters, 2) progress and achievements of directed research on predators, 3) prey monitoring, and 4) specification of environmental data. The group considered 24 working papers addressing these items.

The Group conducted an extensive review of research, being or proposed to be, conducted at CEMP selected monitoring sites. A document was reviewed which provided comments from the Scientific Committee on Antarctic Research (SCAR) Bird Biology Sub-Committee concerning the research at the CEMP sites. Several modifications, including additions and deletions of directed research on specific species, were made based on the SCAR report.

The standard methods for monitoring parameters of predatory species were reviewed. Based on members' experiences in using the instructions and results from sensitivity analyses, major revision and reorganization were recommended for most standard methods. The draft forms for recording field data and reporting summary data were then reviewed. In many cases, revisions were completed to accommodate changes in the standard methods.

The collection of environmental data required to monitor predator and prey species was investigated. The information required to collect environmental data was divided into two categories, environmental features that have a direct influence on predators and environmental conditions that have an indirect effect through their impact on the prey. Features that have a direct influence on predators (e.g., sea ice, local weather) should be the emphasis at land-based monitoring sites. The Group decided that features that have an indirect effect on predators (e.g., water circulation, productivity) should be considered in association with the distribution and abundance of prey and should be addressed by the CCAMLR Working Group on Krill. The Group noted that remote sensing using satellites should play an increasing role in the acquisition of key environmental data. In particular, satellite imagery data on sea-ice distribution and global-scale maps of phytoplankton concentrations and distribution are valuable. (R. Holt, FTS 893-7601)

COASTAL FISHERIES RESOURCES DIVISION

La Jolla, California

COMMERCIAL AND RECREATIONAL FISHERIES RESEARCH FOR MANAGEMENT

Pacific States Integrated Fisheries Economic Model: PSIFEM

Drs. Samuel Herrick, Jr. and Dale Squires, Industry Economists, and Dr. Jack Doll, Summer Faculty Fellow, report significant progress in the development of the Pacific States Integrated Fisheries Economic Model (PSIFEM). PSIFEM is a positive quadratic programming model that is initially being developed to assess the economic consequences of changing biological and economic conditions within West Coast groundfish, pink shrimp, and joint venture whiting fisheries. Essentially, it extends the linear programming model for these fisheries, being developed by Squires, by incorporating ex-vessel supply and demand relationships into the linear program (LP) framework.

PSIFEM is a more general model, in that it relaxes the restrictive assumptions of LP, namely that prices facing fishermen are constant, the costs of catching fish are also constant, and production from a particular fishing activity simply expands until some resource is exhausted. Therefore, the number of non-zero fishing activities will equal the number of binding resource constraints. In the West Coast groundfish fishery it is not unusual for a fishing firm or fleet to engage in a number of distinct fishing operations in which the output is a particular species or mix of species. It is unlike-

ly that the number of truly fixed constraints would equal the number of observed fishing operations.

Because PSIFEM allows for increasing costs and decreasing prices, the number of observed fishing operations can differ from the number of binding constraints since their perceived marginal benefit and marginal cost calculations can equalize at the empirically observed output levels. Furthermore, by accounting for shifts in supply and demand of fisheries outputs, PSIFEM is able to predict the welfare or cost-benefit implications when analyzing a variety of policy issues, for example:

1. What if an energy crisis occurs that leads to a significant increase in fuel prices or fuel shortages?

2. What if trade policies are altered to favor increased U.S. imports/exports of fisheries products?

3. What if allowable catches are changed for West Coast target species?

4. What if limited entry, or a system of individual fisherman quotas is introduced into the West Coast groundfish fishery?

A PSIFEM analysis of such issues will not only predict the fleet response in terms of adjusted fishing patterns, but also changes in the net economic benefits accruing to both fishermen and consumers. All results are conditional upon the status of the fishery resources over the time period of the data used to estimate the model.

During July-August 1989, some major conceptual issues regarding the specification of supply and demand relationships for different fish species and gear types were resolved. This permitted the researchers to proceed with the development of some preliminary models, for a subset of the fishery, for which Doll has provided calibration algorithms using GAMS (General Algebraic Modeling System) language. (S. Herrick, FTS 893-7111; D. Squires, FTS 893-7113)

Groundfish Stock Assessment

Dr. Larry Jacobson, Fishery Biologist, participated in the Pacific Fisheries Management Council (PFMC) Groundfish Management Team's ad hoc review of stock assessments. The review was held at the Tiburon Laboratory, August 7-9. At the meeting Jacobson discussed, with state and NMFS colleagues, a proposed approach for assessment of shortspine thornyhead stocks. He also obtained logbook data for bottom trawl catches landed in California during 1978-1986, and length composition data for shortspine thornyhead landed in California during 1978-1988. His goal is to develop an assessment of the shortspine thornyhead stock for use by the Groundfish Management Team and the PFMC during the 1990 management cycle. (L. Jacobson, FTS 893-7117)

Anchovy Management

At the PFMC meeting held in San Diego on July 13, Industry Economist Cynthia Thomson, Fishery Biologist Larry Jacobson, and Chairperson Rick Klingbeil (CDF&G) were appointed to the Anchovy Fisheries Management Plan (FMP) Team. The team has been charged with drafting two amendments to the existing FMP. The first amendment would allow a small reduction fishery under certain circumstances when the estimated spawning biomass is below the current cut-off level for reduction fishing. The second amendment stems from a requirement in the recently revised NOAA guidelines for fishery management plans that requires each FMP to include an explicit definition of overfishing. The team met for the first time August 25 at the SWFC, developed a timetable for its work, discussed preliminary options, and assigned the tasks of preparing an analysis of each option to specific individuals. It is hoped that the final version of the revised FMP will be adopted by the PFMC in March.

Larry Jacobson, Mathematician Nancy Lo, and other Coastal Fisheries Resources Division (CFRD) colleagues have outlined approaches to: 1) evaluating the information requirements and precision of the Stock Synthesis Model currently used to estimate annual spawning biomass for the PFMC, and 2) calculating confidence intervals for spawning biomass estimates. They plan to complete their analyses in time for use by the NMFS

and PFMC during 1990. (L. Jacobson, FTS 893-7117; C. Thomson, FTS 893- 7116).

Extent of "Avidity Bias" in Angler Surveys Revealed

Cynthia Thomson has completed a paper entitled "The Effect of the avidity bias in on-site angler surveys on estimates of fishing effort and economic value." While on-site surveys are often more cost-effective than other sample selection techniques, they typically generate samples that are biased toward more frequent anglers. This paper compares the "avidity bias" associated with two surveys: 1) the Marine Recreational Fishery Statistics Survey (MRFSS), an on-site creel survey of recreational anglers, and 2) the Bay Area Sportfish Economic Survey (BASES), an economic survey conducted as a mail follow-up to a random telephone canvass.

The results indicate that the avidity bias is much larger for the MRFSS Intercept respondents than the BASES respondents. This bias carried over into estimates of annual fishing expenditures and consumer surplus, resulting in estimates of annual economic value per angler that are 1.5 to 4.0 times larger for the Intercept than the BASES respondents. Given that the BASES sample is itself biased toward more avid anglers, these figures are probably conservative estimates of the "true" magnitude of the bias in the MRFSS Intercept relative to the angling population as a whole.

The paper offers the following general conclusions:

1. Estimates of economic value can be significantly affected by the extent of avidity bias in the sample.

2. Angler expenditures are not necessarily proportional to the number of trips taken. The relationship between expenditures and avidity may be more complicated, either offsetting or exacerbating the effect of the avidity bias in the sample.

3. The sensitivity of consumer surplus estimates to the avidity bias is affected by the functional form of the travel cost model used to generate these estimates.

The paper will be presented at the International Symposium and Workshop on Creel and Angler Surveys in Fisheries Management in Houston, Texas in March 1990. (C. Thomson, FTS 893-7116)

SURVEY SYSTEMS DEVELOPMENT AND EVALUATION

Cruise Planned to Evaluate Use of ROV For Biomass Estimation

The Coastal Fisheries Resources Division is planning a jointly-funded cruise with two vessels to develop new survey techniques for estimating the biomass of demersal fisheries resources. The cruise is funded jointly by the Southwest Fisheries Center and National Undersea Research Program (NURP). The cruise will involve two ships, the F/V *Gus D* chartered by the SWFC and the R/V *William A. McGaw* chartered by Sachse Engineering Associates. Sachse Engineering was awarded the contract by NURP to operate a towed vehicle with side-scan sonar, video cameras and a 70 mm survey camera. The vehicle will be towed over depths of 100 to 700 fathoms and cameras and sonar will be used to provide a census of bottom fishes. To compare abundance estimates provided by the ROV to those provided by conventional trawling, the F/V *Gus D*, a commercial trawler, will trawl over the same grounds surveyed by the ROV. The ROV will also be towed over untrawlable grounds to determine how the density of groundfish differs between trawlable and untrawlable areas.

Cruise dates have been set for September 28 on the *McGaw* and September 29 on the *Gus D*. SWFC personnel participating in the cruise will be Cruise Leader John Butler, Richard Charter, and Cindy Meyer (SWFC), and Pete Adams (Tiburon Laboratory) on board the *McGaw*. Cruise Leader Eric Lynn, Ron Dotson, Sue Miller and Wayne Samiere (Tiburon Laboratory) will be onboard the *Gus D*. The two vessels will rendezvous off Morro Bay on September 29 to begin work.

A one day shake-down cruise on the R/V *Blue Horizon* with the SWFC and Sachse Engineering has been scheduled for September 22. This cruise will determine sampling procedures and operational height of the ROV and calibrate the strobes for the survey camera. (J. Butler, FTS 893-7149).

FISHERY-MARINE MAMMAL INTERACTIONS DIVISION

La Jolla, California

BIOLOGY ASSESSMENT PROGRAM

Studies Are Under Way on Effects of Seal Bombs

Under the 1988 amendments to the Marine Mammal Protection Act (MMPA), the Secretary of Commerce is required to conduct a study to determine that the use of seal bombs (class C explosives) does not cause injury to, or increase the mortality of, dolphins when the bombs are used to control the dolphins during yellowfin tuna purse-seining operations. In response to the MMPA requirement, Wildlife Biologist Al Myrick has been exploring different avenues of inquiry into the effects of seal bombs on dolphins. One of these involves conducting open-water tests of seal bombs on inanimate objects and dolphin carcasses to determine whether mechanical damage can be done to the targets by underwater seal-bomb explosions. Another study involves the monitoring of set log data for years 1986-1989 to determine percent use of seal bombs on dolphins, and to estimate annual numbers of dolphins potentially exposed to bombs. A third study, now in its early stages, will involve examining inner ear tissue of purse-seined dolphin carcasses for evidence of hearing damage.

Since July, tests have been conducted at sea using both the legal, Class-C seal bombs and illegal foreign-made bombs (over 40 grains of explosive). Using an electric detonator, the bombs were exploded remotely on target objects. Gelatin-filled bottles containing air-filled balloons and water- and air-filled metal cylinders were used as targets to simulate organ systems, and dolphin carcasses were used to simulate whole live animals. With considerable assistance from Chuck Oliver and the SWFC dive team, targets were deployed at various depths and distances from the detonation site and fired on. After the tests, the targets were examined for damage.

Observers have been trained in the collection of ear bones (cochlea) and a call has been made to observers at sea to begin cochlea sampling. Samples received by he SWFC will be forwarded to a noted specialist for examination and evaluation. A report of the study should be available in November.

Results of these and other studies in the SWFC's seal-bomb investigations will be reviewed and finalized at a Seal Bomb Workshop to be held at the SWFC in mid-November. The workshop will be attended by a small group of experts representing industry, the environmental community, and specialized fields covered in this study. (A. Myrick, FTS 893-7092).

FISHERY DEPENDENT ASSESSMENT PROGRAM

Report on Blue Whale Distribution in The Eastern Tropical Pacific

Dr. Steve Reilly, Fishery Biologist, and Victoria Thayer, Oceanographer, have just completed a manuscript describing the distribution of blue whales in the eastern tropical Pacific Ocean (ETP). The classical, and general, depiction of blue whale distribution includes a seasonal migration to high latitudes where they feed extensively on euphausiids, then to low latitudes where, it is thought, they rarely feed but rather mate and give birth. Foraging has not been considered a major factor in their low latitude distribution. From the patterns of blue whale distribution in the ETP, Reilly and Thayer hypothesize that forage availability may be an important determinant of blue whale habitat in low latitudes.

Figure 1 shows the distribution of blue whales in the ETP studied from 211 sightings of 355 whales recorded during research vessel sighting surveys and by biologists aboard fishing vessels. All sightings occurred in relatively cool, productive upwelling-modified waters along Baja California, the equator near the Galapagos Islands, the northern coast of South America, and around the Costa Rican Dome (a large, stationary eddy centered at 9°N, 89°W). Occupation of the most productive parts of the ETP, all with relatively large standing stocks of euphausiids, indicates that blue whales may select low latitude "breeding" areas which also permit foraging.

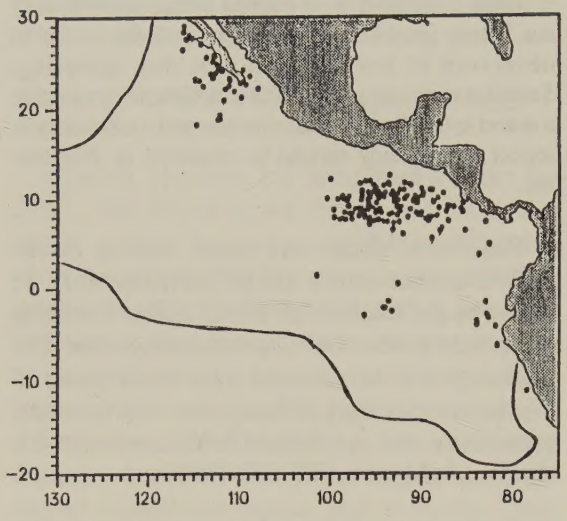

Figure 1. Spatial distribution of 211 blue whale sightings in the eastern tropical Pacific, 1974-1988. The boundary line encloses the area in which there was at least 185 km search effort per one degree latitude-longitude square.

Baja California was occupied seasonally, with a sighting peak coinciding with the spring peak in upwelling and biological production. The Costa Rican Dome and nearby areas on the eastern-most and shallowest end of the prominent ridge in the thermocline undergo very little seasonal variation in both physical and biological processes. This discrete area was occupied year round, suggesting either a resident population or that both northern and southern hemisphere whales visit, with temporal overlap and potential for interbreeding. The modal group size was one for all areas and seasons, but the frequency of groups with two or more whales was significantly higher in sightings made near the Galapagos Islands and coast of South America. (S. Reilly, FTS 893-7164).

HONOLULU LABORATORY

Honolulu, Hawaii

U.S.-Japan Cooperative Seminar on *Sebastes*

Scientists from the United States, Japan, and Canada met in Honolulu, June 26-30, 1989, for a cooperative seminar, Rockfishes of the Genus *Sebastes*: Their Reproduction and Early Life History. A major goal of the seminar was to provide U.S. and Japanese scientists the opportunity to share their knowledge and examine alternative approaches to the study of *Sebastes*. The seminar, which was held at the East-West Center on the University of Hawaii-Manoa campus, was jointly funded by the International Programs Division of the National Science Foundation (NSF) and the Japan Society for the Promotion of Science. The organizers of the seminar were George W. Boehlert, Director of the Honolulu Laboratory, and Juro Yamada from the University of Hokkaido, Hakodate, Japan.

In both the United States and Japan, the primary impetus for research on *Sebastes* has been its importance to marine fisheries, but the secondary impetuses have differed: Japan has focused on aquaculture potential, and the United States on basic ecology pertinent to fisheries. As a result, the two countries use different approaches to the study of reproductive biology and early life history of *Sebastes*. For example, Japan has developed an energetic aquaculture industry to replenish the coastal marine resources, while the United States concentrated on natural production and management of stocks.

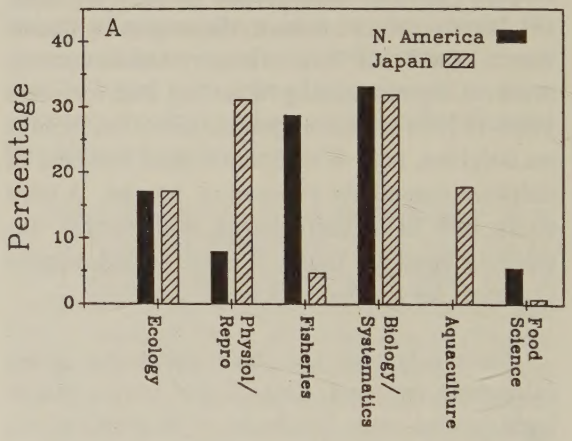

Figure 1A. Differences in research effort on rockfishes in North America and Japan as shown by publications. Data for North America are based upon 456 references from a published bibliography by Maureen Leet of the Tiburon Lab. in 1988. Those from Japan are based upon 129 references from a bibliography by Koji Ikehara of the Japan Sea Regional Fisheries Research Lab. in Niigata. Each paper was selected on the basis of whether the genus *Sebastes* or *Sebastodes* or the word rockfish appeared in its title and was categorized according to the content implied by its title.

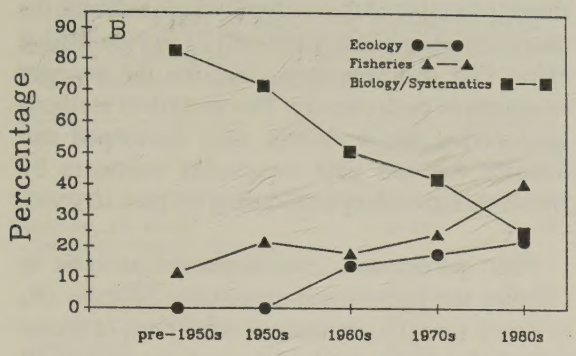

Figure 1B. Changes in the direction of research on rockfishes in North America over time.

An examination of pertinent publications demonstrates the differences between research approaches in Japan and North America (United States and Canada). Research papers on *Sebastes* in North America focus largely on biology, systematics, fisheries, and ecology and, to a lesser extent, reproduction, physiology, and food science (Figure 1A). On the other hand, Japanese publications are mostly on reproduction, physiology, biology, and systematics and, to a lesser extent, aquaculture, ecology, and fisheries. Early research in North America was dominated by papers on systematics and basic biology, but recent decades have seen an increase in studies on fisheries and ecology (Figure 1B).

The 24 scientists attending the meeting presented papers on the reproduction, physiology, life history, and aquaculture of rockfish. Many of the papers resulted from a 4-year, NSF- sponsored, cooperative research program between U.S. and Japanese scientists. NOAA Fisheries was well represented, with coauthorship on 12 of the 25 papers presented.

The North American participants made several ties for future cooperative research and learned a great deal from their Japanese colleagues about new research on reproduction in *Sebastes*, including a paper and a video presentation on mating behavior and copulation. Applications of reproductive and ecological research were considered in several papers on aquaculture. Some papers examined the feasibility of raising commercially-important rockfish in hatcheries for later release in the wild. Pilot studies in Japan--where raising young rockfish is much more advanced than in the United States--have involved raising rockfish to a viable size and then releasing them in the open ocean. Later, these rockfish may be cap-

Participants of U.S.-Japan Cooperative Seminar. Front row (left to right): Hiroya Takahashi, Hokkaido Univ.; Bruce Leaman, Pacific Biol. Station, British Columbia; Milton Love, Univ. of California, Santa Barbara; Ralph Larson, San Francisco State Univ.; Akihiko Shinomiya, Univ. of Kagoshima; Kazunori Takano, Hokkaido Univ.; Motohiro Shimizu, Hokkaido Univ. Second row: Teruyuki Nakanishi, Japan Nat. Res. Inst. of Aquaculture; Muneharu Kusakari, Hokkaido Central Fish. Exp. Station; Maxwell Eldridge, Tiburon Lab.; John Wourms, Clemson Univ.; Leslie Williams, Honolulu Lab.; Akihiro Takemura, Hokkaido Univ.; Tina Wyllie Echeverria, Univ. of Alaska-Fairbanks; Juro Yamada, Hokkaido Univ.; Jeannette Whipple, Tiburon Lab.; Yoshitaka Nagahama, Japan Nat. Inst. Basic Biol.; Lisa Seeb, S. Illinois Univ. Third row: Lewis Haldorson, Univ. of Alaska-Southeast; Arthur Kendall, Jr., Alaska Fish. Sci. Center; Jeffrey Polovina, Honolulu Lab.; George Boehlert, Honolulu Lab.; Mary

tured as adults by commercial fishermen. Such hatchery releases may help prevent natural populations of rockfish from becoming depleted, but have not been proven to be effective as yet.

The papers presented at the meeting are being reviewed for publication as a dedicated volume of Environmental Biology of Fishes and in book form as a companion volume in the series Developments in the Environmental Biology of Fishes, which will be edited by Boehlert and Yamada. (G. Boehlert (808) 943-1211)

INSULAR RESOURCES INVESTIGATION

NOAA-UH Tropical Stock Assessment Workshop Held in Honolulu

The Tropical Assessment Workshop was held in Honolulu, July 5-26, 1989, to assist fishery scientists from selected Pacific island countries (Figure 3) in analyzing their research and commercial catch and effort data on deepwater snappers. The workshop was convened by NOAA Fisheries and the University of Hawaii's School of Ocean and Earth Science and Technology, with funding provided by NOAA and the U.S. Agency for International Development. Workshop participants were from the Cook Islands, Fiji, Kingdom of Tonga, Papua New Guinea, Solomon Islands, Tuvalu, Vanuatu, and Western Samoa. The ultimate objective of the analyses was to estimate the maximum sustainable yield (MSY) and the fishing effort that achieves this yield for the snapper resources in each country. The analytical methods used during the workshop were developed and adapted for use with deepwater snappers by Honolulu Laboratory staff during the past 10 years.

Figure 3. Participants of the Tropical Assessment Workshop. Front row (left to right): Paul Lokani, Donald Kobayashi, Helen Pili, Gideon Tiroba, Ned Howard, M. Kimberly Smith, Apisai Sesewa, and Richard Shomura. Second row: Albert Carlot, Gianandar Nath, Ronald Benco, Taniela Sua, Tevita Latu, Esperance Cillaurren, Jeffrey Polovina, Paul Dalzell, and Sosaia Tulua.

First, participants used depletion analysis to estimate the unexploited exploitable biomass (B_o in metric tons (t)) per nautical mile (nmi) of 200 m isobath from the catch rates and catches at 18 heavily fished locations (Table 1). Except for a few outliers, most estimates of B_o cluster around the median values of 2.7 t/nmi for seamounts and 0.7 t/nmi for islands.

Table 1. Length of 200 m isobaths and biomass per nautical mile (B_o/nmi) of 200 m isobath for all depletion analyses.

Location	Nautical mile	Unexploited B_o/nmi
Seamounts		
Kavieng	0.25	3.30
1004	1.20	8.50
Pathfinder	3.00	2.00
Tavenui	3.10	2.50
Napuka	4.20	3.80
801	5.00	2.70
901	6.80	2.70
Savusavu	7.90	1.40
Grid 147	13.10	7.00
Kadavu	18.00	1.50
903	35.00	2.40
		Median = 2.70
Island		
Paama	28.00	2.30
Schoutten Islands	33.00	0.20
Moon Reef to Ellington	40.00	0.60
Grid 482	40.00	0.55
Ovalau to Moon Reef	42.00	0.70
Nasilai to Ovalau	50.00	0.70
Ambae	62.00	0.70
		Median = 0.70

Since the bottomfish fisheries are just beginning to be exploited, no time series of catch and effort data is available for the production models. Thus, workshop participants estimated MSY as a fraction of B_o by using Beverton-Holt, Gulland, and Pauly's methods: ratios of MSY to B_o were about 10-30% (Table 2). For natural mortality (W) equaling 0.25, a lower bound of MSY estimated at 9% B_o was obtained. For the Beverton-Holt method with M equaling 0.5 and Pauly's method, which depends only on fish weight, MSY was estimated at about 30% B_o. Therefore, the range of 10 to 30% B_o includes the true value of MSY.

Estimates of MSY for each Pacific island were determined as the product of MSY per nautical mile of 200 m isobath for each country and the total

Table 2. Ratios of maximum sustainable yield (MSY) to biomass (B_o) for the three methods (Gulland, Beverton-Holt, and Pauly).

	MSY/B_o M=0.25	MSY/B_o M=0.5
Gulland (0.5 m)	0.13	0.25
Beverton-Holt when m/k=2		
Age at recruitment		
3 years	0.06	0.18
4 years	0.09	0.28
Pauly $(2.3\ w)^{-0.26}$		
Marianas	0.34	
Papua New Guinea	0.28	
Western Samoa	0.27	
Vanuatu	0.32	
Tonga	0.28	

length of the 200 m isobath (Table 3). For Tonga, current landings from the seamounts are almost twice the upper bound of estimated MSY, and fishing mortality (F) is about equal to M. This suggests that fishing effort in Tonga is at the level that produces the MSY, and once the seamount fishery reaches its equilibrium, catches and catch per unit effort will be substantially lower.

Table 3. Estimates of maximum sustainable yield (MSY), landings, and fishing mortality (F) for deepwater snappers at selected Pacific island countries in 1988 (t = metric tons).

Country	MSY (t/year)	Landings (t/year)	F/year
Tonga	77-222	391	0.38
Western Samoa	17-50	25	--[a]
Fiji	70-200	300	0.12
Fishing area of 500 nmi of 200 m habitat now being fished			
Fiji	426-1,280	0	0
Potential fishing area of 3,000 nmi			
Papua New Guinea	170-270	0	0
Vanuatu	113-190	40	0.07

[a]No estimate of q was available to estimate F.

In western Samoa, the deepwater snappers are already close to MSY although some increase is possible, and in Fiji, the fishery is using only about 20% of the estimated 3,000 nmi of 200 m isobath and thus has the potential to increase catches if this unfished habitat has populations of deepwater snappers. However, if the fishery remains only within the habitat currently fished, catches will decline, perhaps by 50%. In Fiji, the current level of fishing effort may be a little lower than the level that produces MSY. Papua New Guinea has no appreciable landings of deepwater snappers, but a potential exists with MSY in the range of 170-270 t/year. Vanuatu's landings represent only one-third to one-fifth of the potential MSY, as indicated by the current landings and level of F, so the potential exists for greater landings.

The Honolulu Laboratory staff that provided assistance to this workshop included: Jeffrey J. Polovina, Program Manager of the Insular Resources Investigation; David A. Somerton, Leader of the Insular Stock Assessment Program; NRC-NOAA Postdoctoral Fellow M. Kimberly Smith; Computer Programmers Ronald A. Benco and Donald Kobayashi; and Biological Technician Happy A. Williams. The results of these analyses were presented in reports written by the participants and will be published in the NOAA Technical Memorandum Series. (J. Polovina (808) 943-1218)

PELAGIC RESOURCES INVESTIGATION

Pacific Blue Marlin Tracked Successfully

Two Pacific blue marlin, *Makaira mazara*, carrying depth-sensitive, ultrasonic transmitters were tracked successfully by Fishery Biologist Richard W. Brill of the Honolulu Laboratory, Kim Holland of the University of Hawaii's Institute of Marine Biology, and NOAA Corps Officer LTJG Scott Sullivan off the Kona Coast, island of Hawaii, July 28 to August 6, 1989. The fish were caught and released by anglers participating in the 31st Annual Hawaiian International Billfish Tournament in Kailua-Kona.

Both fish behaved remarkably similar to three marlin tracked in the summer of 1988, although they were captured and released about 10 nmi south of last year's capture site. After release, the two fish moved directly offshore and along parallel courses for approximately 10 nmi. This offshore movement appears to be a stereotypical response of marlin to the stress of capture. Both fish eventually turned north and proceeded in that direction for the duration of the tracking. With respect to swimming depth, both fish moved up and down only within the mixed layer (i.e., the 50-100 m layer of uniform water temperature). Further analysis of the data is proceeding. (R. Brill (808) 943-1234)

Brill Attends Two International Conferences

Fishery Biologist Richard W. Brill attended the Kjell Johansen Commemorative Symposium, Strategies of Physiological Adaptation, at the August Krogh Institute in Copenhagen, Denmark, July 6-8, 1989, and the XXXI Congress of Physiological Sciences in Helsinki, Finland, July 9-14, 1989. At the symposium in Denmark, Brill presented a poster, "Temperature effects on the acid/base balance of isolated whole blood and plasma of yellowfin tuna (*Thunnus albacares*)," which was coauthored with David Jones and Peter Bushnell, who are with the University of British Columbia.

The poster described a re-investigation of the unusual rates of pH change with temperature previously reported in isolated tuna blood. Tunas often subject themselves to rapid temperature changes during vertical movements, which are a regular part of their behavior. Also, because they have countercurrent, vascular heat exchangers, their muscle temperatures may be as much as 10°-15°C above ambient. Tuna blood is therefore regularly subjected to rapid temperature changes in open (i.e., in the gills) and closed systems (i.e., in the vascular heat exchangers). Understanding how tunas regulate their blood acid-base balance is therefore critical to understanding their habitat requirements and temperature tolerances.

The effects of temperature on the acid-base balance of the blood of skipjack tuna, *Katsuwonus pelamis*, were first investigated in vitro by S. F. Perry and others, who found similar rates of pH change with temperature in open (i.e., constant pCO_2) and closed systems (-0.0131 and -0.0165 pH units/°C, respectively) (cf. Comp. Biochem. Physiol. 81A:49- 53, 1985). These data contrast sharply with those for marine seatrout, *Cynoscion arenarius*, which have more typical rates of pH change with temperature (-0.0048 and -0.0150 pH units/°C in open and closed systems, respectively) according to a study by J. N. Cameron (Respir. Physiol. 33:129-144, 1978). Perry and others postulated that the unusual rates of pH change with temperature in tuna blood were an adaptation related to the unusual anatomy, physiology, and lifestyle of these pelagic teleosts. Blood from albacore, *Thunnus alalunga*, also exhibits a high rate of pH change with temperature (0.016 pH units/°C) in the open system, according to a study by J. J. Cech and others (J. Exp. Biol. 109:21-34, 1985).

The study described in the poster used blood from small (ca. 1-3 kg) yellowfin tuna, equilibrated at temperatures inhabited by this species and at $C0_2$ levels corresponding to normal arterial and venous blood values. Results showed that the yellowfin tuna blood had an unusually high HCO_3 and non-bicarbonate buffering capacity when compared with other teleosts. Tuna blood and plasma had the same rates of pH/°C and pCO_2/°C in a closed system as other teleosts; this result was expected since these changes were most likely due to reciprocal titration of plasma proteins and HCO_3. Tuna red blood cells appeared to be involved in the unusually high pH/°C and $[HCO_3]$/°C changes occurring in the open system. The pH/°C changes in the open system were pCO_2 dependent and independent of $[HCO_3]$/°C changes, most likely reflecting the movement of strong ions into or out of red blood cells. The study is part of a larger effort aimed at understanding the in vivo regulation of acid-base status in tunas.

At the symposium in Finland, Brill presented an invited lecture, "Comparative physiology of animal athletes: Tunas and other fast fishes." His lecture centered on the new concept that the unique anatomy, physiology, and biochemistry of tunas have evolved not to permit exceptionally high sustained swimming speeds, but rather to permit rapid repayment (i.e., rapid lactate metabolism) of the exceptionally large oxygen debts (i.e., high muscle lactate levels) that tunas are capable of accumulating. Previously, tunas were assumed to be like human athletes: good marathoners. Brill pointed out that these terms are inappropriate despite the title of the lecture, because the unique environment in which tunas live does not lend itself to description by analogy to situations in the terrestrial environment. Brill's lecture was part of a symposium on the physiology and biochemistry of elite animal athletes. (R. Brill (808) 943-1234)

MARINE MAMMALS AND ENDANGERED SPECIES PROGRAM

Head Start Project Releases Female Monk Seal Pups

According to Fishery Biologist John Henderson, the Head Start Project at Kure Atoll completed another successful year on August 7, 1989, with the release of four female Hawaiian monk seal, *Monachus schauinslandi*, pups. The pups had

been maintained in a protective enclosure on Green Island at the atoll since weaning earlier this year.

Initiated in 1981, the Head Start Project is designed to increase the survival of weaned female pups at Kure Atoll, where first- year survival of pups was very low during the 1960's and 1970's. By maintaining female pups in a wire mesh enclosure, the Project protects them from two of the sources of first-year mortality: adult male seals and tiger sharks, *Galeocerdo cuvieri*, both of which are known to attack weaned pups. During the field season at Kure Atoll, staff and volunteers of the Marine Mammals and Endangered Species Program maintain the protective enclosure, trap locally occurring reef fish to feed the female pups during their time in captivity, and also monitor the monk seal population.

The Head Start Project also "rehabilitates" abandoned or otherwise prematurely weaned, female monk seal pups from French Frigate Shoals, where the monk seal population may be near carrying capacity. Female pups collected from the shoals are flown to Honolulu for rehabilitation and subsequently released at Kure Atoll, after being held in the protective enclosure to ensure they are able to feed on their own. This year, three rehabilitated female seals, originally captured in 1988, were added to the Kure population. They were transported to Kure Atoll in April and maintained in the protective enclosure until being released in late May. Two of the females were sighted at Kure Atoll throughout the summer, but the third was not sighted, having either emigrated or died.

Ten pups were born at Kure Atoll in 1989; nine survived to weaning. This is the highest number of births documented at the atoll since 1981 and is a marked increase since the low of one birth in 1986. Furthermore, female seals that were "graduates" of the Head Start Project in its early years are now giving birth. With a relatively large cohort of young females approaching reproductive age, the number of births at Kure Atoll is expected to continue to increase. (J. Henderson (808) 943-1225)

Research Successfully Completed on Laysan Island and Pearl and Hermes Reef

The annual field research directed at monitoring the Hawaiian monk seal, *Monachus schauinslandi*, and green turtle, *Chelonia mydas*, on Laysan Island and Pearl and Hermes Reef was completed on August 2, 1989, by Wildlife Biologist Brenda L. Becker, with the assistance of several volunteers. Preliminary results from the 3.5-month field camp at Laysan Island indicated that a minimum of 32 pups were born in 1989, which is about average for this island. The minimum survival rate (60%) of the yearling monk seals was lower than normal (80-90%), but births (N=45) in 1988 were the highest on record since 1977, when intensive research efforts began at Laysan Island.

Thirteen mortalities of seals were documented at Laysan Island; half (seven) were adult females. Injuries due to mobbings by adult males were present on eight of the carcasses (i.e. , all seven of the adult females and one subadult male). Only one mobbing incident, which was not fatal, was observed; it involved a 5-year-old adult female and at least five adult males. One of the mortalities was of an immature seal whose skull and attached foreflipper were found in the stomach of a dead tiger shark, *Galeocerdo cuvieri*, that washed ashore. This is the first documented case of a monk seal skull being discovered inside a shark. Three seals were found entangled in marine debris; one incident required physical restraint to remove a small tire from an adult female.

Turtle nesting activity on Laysan Island was quite low--only nine nests. Three adult turtles with fibropapillomas (tumors) were sighted during the field season, compared with one sighting of a diseased turtle in 1988. Last year's sighting was the first on record at Laysan Island, although the number of turtles exhibiting fibropapillomas has been increasing around the main Hawaiian Islands. One of the diseased turtles sighted in 1989 had tumors on its eyes, and during the field season, its left front flipper was partially amputated, presumably by a tiger shark. Loss of vision due to the tumors probably made the turtle more vulnerable to shark attack.

After the Laysan Island field season, researchers spent 2 weeks at Pearl and Hermes Reef conducting census counts as well as individual identification of monk seals via tags and identifying marks (i.e., scars). Fourteen pups were tagged, no mortalities were documented, and one entanglement was observed. Turtle nesting activity was again minimal. (B. Becker (808) 943-1265)

Tumors Continue to Spread in Hawaiian Green Turtles

The incidence of fibropapillomas, a life-threatening tumor, has substantially increased in an important aggregation of the Hawaiian green turtle, *Chelonia mydas*, which resides along the southern coast of the island of Molokai and, prior to 1985, had no known cases of the tumors. According to George H. Balazs, Leader of the Marine Turtle Research Task, tag and recapture work performed in July 1989 indicates that 14 of 143 turtles (9.8%) captured off Molokai had tumors, compared with 6 of 125 turtles (4.8%) during the same period in 1988. The etiology of this disease, its mode of transmission, and its impact to the biological recovery of the green turtle population in Hawaii are presently unknown. Scientists also have yet to pinpoint why the disease has spread simultaneously at certain sites in Hawaii and Florida during the past few years.

The periodic monitoring and tagging of immature and adult green turtles at Palau has been under way since May 1982, in cooperation with Bill Puleloa, an Aquatic Biologist with the State of Hawaii, and Ed Medeiros, a local fisherman who is well versed in the capture of sea turtles. During 1982-85, approximately 300 turtles were captured, examined, tagged, and released without any cases of tumors being seen. However, one of the turtles captured in October 1985 was heavily afflicted with these debilitating epithelial growths; the second diseased turtle was captured in June 1987.

Increased effort will be directed at monitoring the incidence of tumors at other coastal habitats preferred by turtles in the Hawaiian Islands. In addition, cooperative studies were initiated in Hawaii with researchers at the Universities of Florida and Chicago in concordance with the priority position assigned to this problem in the Recovery Plan for Hawaiian Sea Turtles. (G. Balazs (808) 943-1221)

FISHERY MANAGEMENT RESEARCH PROGRAM

Midyear Fishery Reports

The source of greatest controversy in Hawaii's commercial fisheries in 1989 is the emerging conflict between a group of recently arrived longline fishing boats from the Gulf of Mexico and small-scale recreational, commercial, and charter boats off Oahu's Waianae coast and on Haleiwa's fishing grounds. The topic dominated discussions at the July 24-26, 1989 meeting of the Western Pacific Regional Fishery Management Council in Kahuku, Oahu. By mid-August, the two sides involved in the conflict had attended several meetings held by Council Chairperson William Paty, and informal "rules of the road" had been proposed. Neither Federal nor State of Hawaii regulations on the pelagic fisheries have been applicable to this situation.

The potential for conflicts over markets, resources, and gear has increased over the past couple of years as the longline tuna fleet expanded--from as few as 16 vessels in 1980 to 37 vessels in 1987 to at least 65 vessels in 1989. At the same time, the commercial, charter boat, and recreational trollers have expanded in number and are fishing farther from shore. Some of the newer longline vessels fish their gear in shallower depths (some immediately subsurface) and closer to shore, catching a higher percentage of striped marlin, *Tetrapturus audax*, and yellowfin tuna, *Thunnus albacares*, than most of Hawaii's longline fleet. This summer, a few of the new longline boats began fishing near fish aggregating devices (FAD's) located 3.5 to 5 miles off the coasts of Oahu and Kauai. This led to a period of intense gear competition, because over the past few years, the FAD's have been used almost exclusively by trollers. Although a number of Honolulu Laboratory scientists have been asked for technical assistance during the controversy, information on the biological and economic interactions in these nearshore pelagic fisheries is, at best, weak.

Meanwhile, the longline fishery for pelagic fishes and tunas remained strong through the first half of 1989. Landings by the longline fishery in the first quarter of 1989 were similar to the last quarter of 1988, which itself was a record. Tunas comprised 65% of the landings, most of which were bigeye tuna, Thunnus obesus. The largest component in the non-tuna landings was striped marlin. Substantial landings of broadbill swordfish, Xiphias gladius, also were reported this year, the first time that swordfish has been a primary target for Hawaii's boats. Most of the swordfish were exported to the east coast.

Detailed estimates of troll and handline landings in 1989 are not available, but this does not

appear to be a particularly good year, intensifying the interaction problems with the longline fleet.

Logbooks have been collected from a fourth precious coral trip under the experimental permit section of the Precious Coral Fishery Management Plan. Two boats have permits, but only one has fished. Detailed activity data on the fishery cannot be released because of the confidentiality restrictions.

Activity in the bottom fish fishery in the Northwestern Hawaiian Islands (NWHI) was light during the first half of 1989. Only five vessels were active in the fishery in the first half of 1989, making 21 trips. Catch rates on the primary species of red and pink snappers reportedly were not good, although prices have held up well.

Only nine trips by seven vessels were made in the NWHI lobster fishery through June 1989. Vessel and trip activity were lower than in 1988; however, fishing effort, catch rates for spiny lobster, *Panulirus marginatus*, and total lobster catches substantially exceeded the 1988 midyear levels. Not only has fishing been good, but prices also have been higher than in 1988. (S. Pooley (808) 943-1216)

PACIFIC FISHERIES ENVIRONMENTAL GROUP

Monterey, California

FISHERY/ENVIRONMENTAL LINKAGES

Stock Structure and Size Composition

The stock structure of albacore in the North Pacific is presently an unresolved problem. Fishery Biologist Richard Parrish is currently using the extensive length frequency measurements taken in the Japanese baitboat fishery (479,400 fish) and those from the American fishery (318,558 fish) to examine this problem. There is circumstantial evidence which suggests that the traditional U.S. albacore fishery is based on two stocks. A principal piece of evidence is that differences in the growth rates of albacore caught in the northern and southern fishing grounds have been observed (i.e. north and south of 38 degrees North). Growth studies based on a limited number of fish for which daily otolith counts have been made (98 from the northern area and 127 from the southern area) and from tag and recapture data from 521 fish indicate faster growth for fish in the southern area than in the northern area. Tag recoveries suggest that there is more interchange of albacore between the Kuroshio Current region and the northern portion of the California Current region than between the Kuroshio and the southern portion of the California Current, and that there may be two stocks.

The North Pacific albacore fisheries are quite seasonal and occur in different seasons in different regions. Also, albacore grow very quickly and the differences in size distributions between regions is heavily influenced by the interaction of these factors. To limit the seasonal bias, the analysis was limited to fish captured in July and August, when the California Current albacore fishery peaks. The data were divided into bands of 5 degrees of latitude for both the Kuroshio and California Current fisheries to show regional patterns in length frequencies. In the July-August period the catch from the Japanese baitboat fishery is dominated by fish taken in the Kuroshio Extension.

The clearest feature of the data is that all of the regions have a mode at 61-62 cm, representing 3-year old fish (A in Figures 1 and 2). This mode dominates the size composition in each of the regions; with the significant exception of the 30

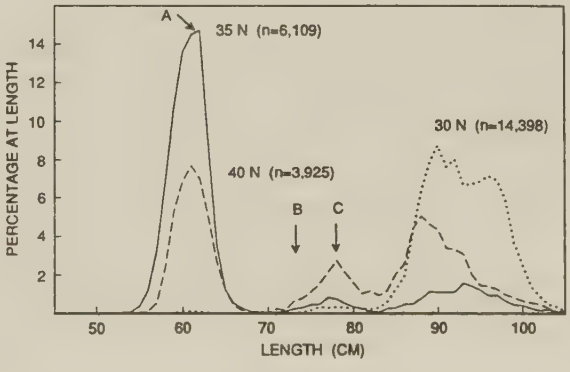

Figure 1. Length frequencies of albacore taken in July-August (1965-82) within 5 degree latitude bands by the Japanese baitboat fishery.

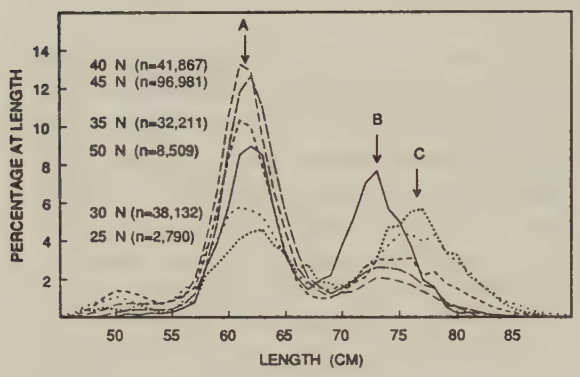

Figure 2. Length frequencies of albacore taken in July-August (1961-84) within 5 degree latitude bands in the California Current Region.

degree bands in the Kuroshio where albacore of this size comprise only a very minor proportion of the size composition and in the most southern 5 degree bands in the California Current where it is the secondary mode. Thus, 3-year old albacore are the same size in July and August in all regions in which they are caught in the North Pacific.

The size of 4-year old albacore is quite a different story. In the California Current region, size composition has a mode at 73 cm in the 40, 45, and 50 degree north bands (B in Figure 2); whereas the mode is at 76 or 77 cm in the 25, 30, and 35 degree north bands (C in Figure 2). In addition, there is a continuous increase in the proportion of fish larger than 73 cm from the north to the south. In the Japanese baitboat fishery there are modes at either 77 or 78 cm at the 30, 35, and 40 degree north bands (C in Figure 1); however, the bulk of the albacore catch in the 30 degree north bands are larger than the mode for 4-year olds.

The evidence from this analysis suggests that the size composition, and presumably the growth rates, of albacore are more similar in the Western Pacific region and the southern portion of the California Current than they are in the northern and southern portions of the California Current or in the northern portion of the California Current and the Western Pacific. Three-year olds appear to be the same size everywhere, and the size of 4-year olds appears to be primarily a function of latitude. (D. Parrish (408) 646-3311)

MATHEMATICAL MODELING AND DATA ANALYSIS

Results Show Long-Term Decline in Albacore Catch Rates

Operations Research Analyst Roy Mendelssohn has been developing predictive models for the West Coast albacore fishery utilizing catch information from the albacore logbook program. As a part of this program, the annual variations in catch rates are being examined. Recent results show that there has been a long-term decline in the number of fish caught per day in the fishery and that the decline has been particularly dramatic in the region which has traditionally provided the bulk of the catch from the northern Oregon-Washington portion of the fishery. During the 1960s, median catches averaged nearly 100 fish per day in the northern fishery, and catches exceeding 200 fish per day were quite common (Figure 3). In the 1970s, median catch per day

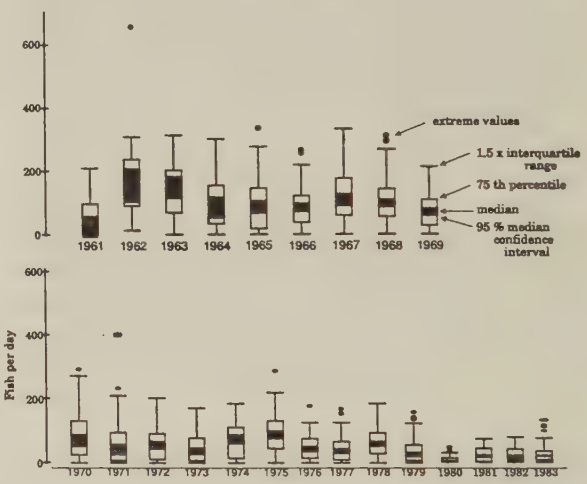

Figure 3. Albacore catch per day, from logbook data, for the region of maximum catch in the northern fishery (i.e. between 40 and 48 degrees north and 50 to 200 km offshore).

declined markedly and catches above 200 fish per day became rare. Catch rates continued to decline in the early 1980s; median catch ran around 25 fish per day and catches of 100 fish per day became rare. (R. Mendelssohn (408) 646-3311)

PELAGIC FISHERIES RESOURCES DIVISION

La Jolla, California

MULTISPECIES DATA COLLECTION AND EVALUATION PROGRAM

Summary of the 1988 North and South Pacific Albacore Data

Anthony Majors, Fishery Biologist, and Christina Perrin, Computer Programmer Analyst, SWFC, and Forrest Miller, IATTC, have completed SWFC Administrative Report LJ-89-19, which summarizes 1988 U.S. Pacific albacore fisheries. Catches of albacore in the northern fishery have increased slightly from 2,900 metric tons (t) in 1987 to 4,800 t in 1988, but are still well below the 20-year average of 16,000 t (1968-87). The average sizes of fish landed in the northern fishery (12.8 lbs), was slightly smaller than those landed in 1987 (14.9 lbs). Catch rates in fish per standard day's fishing increased from 70 fish per day in 1987 to 117 fish per day in 1988.

Participation in the south Pacific U.S. albacore fishery reached its highest level (43 vessels in 1988) since its start in 1986. Catches for the southern fishery increased substantially from 700 t in 1987 to 3,500 t in 1988. Average size of fish caught was 14.9 lbs. (A. Majors, FTS 893-7077; C. Perrin, FTS 893-7078)

STOCK ASSESSMENT AND FISHERY IMPACT ANALYSIS PROGRAM

Tuna Avifauna

Fishery Biologist David Au, has prepared a manuscript comparing the avifaunal characteristics of "log", "school", and "porpoise" associated schools of tuna in the eastern tropical Pacific. Some 1,762 catch records, which were obtained by observers during 1974 and 1975 when much information on species associated with tuna catches was collected, were analyzed. Terns and small shearwaters were most abundant with schoolfish tuna, while boobies, frigatebirds, and the larger shearwaters were more abundant with logs, and especially porpoise-associated tuna. This difference was observed in the occurrence rates of the bird species, and in the flock sizes by species and flock characteristics. It is hypothesized that the avifaunal differences are related to species-specific, aerial foraging tactics used by the birds in pursuit of prey driven to the surface by tuna. (D. Au, FTS 893-7071)

TIBURON LABORATORY

Tiburon, California

GROUNDFISH COMMUNITIES INVESTIGATIONS

Occurrences of First-Year Juvenile Rockfishes in Nearshore Habitats Indicate Weak Recruitment in 1989.

Direct underwater counts of first-year juvenile rockfishes in nearshore habitats along the Mendocino and Sonoma Coasts indicate that the current year-classes of the three major species, *Sebastes flavidus*, *S. mystinus*, and *S. melanops*, are relatively weak. As in previous years, the comparisons between sites and years are based on counts made between August 15 and September 15, by which time virtually all recruits of these species that will settle in the nearshore habitats have done so. This year's counts, which were made by Fishery Biologists Dan Howard and Tony Chess of the Groundfish Communities Investigations, indicate levels of recruitment similar to 1984, another weak year (Tables 1 and 2). In fact, of the three, there were fewer *S. flavidus* and *S. melanops* counted this year than any other year since the El Niño year of 1983.

Despite the relatively low numbers, however, certain patterns noted during previous years remained evident (although less so than during years of greater abundance). Thus, the first-year juvenile *S. flavidus* continued to be more numerous off Mendocino than off Sonoma, while the reverse was true of *S. mystinus*.

Table 1.--Mean number (standard error in parentheses) of first-year juveniles counted/minute off the Mendocino coast during August, 1989. Results from other years provided for comparison. n=number of one minute assessments.

Species	1983 n=36	1984 n=57	1985 n=50	1986 n=103	1987 n=112	1988 n=62	1989 n=184
S. flavidus	0.00	6.58	115.60	6.01	102.66	59.47	2.63
	(0.00)	(2.29)	(21.26)	(1.50)	(11.08)	(10.23)	(0.96)
S. mystinus	0.27	1.49	70.56	7.83	181.04	75.89	6.07
	(0.09)	(0.30)	(15.32)	(1.88)	(26.19)	(10.18)	(0.93)
S. melanops	0.41	0.31	4.34	9.52	7.58	5.94	2.99
	(0.14)	(0.08)	(1.54)	(2.08)	(1.24)	(1.35)	(0.56)
Total	0.68	8.38	190.50	23.35	291.67	141.29	11.69
	(0.19)	(2.33)	(29.82)	(3.91)	(33.99)	(16.88)	

Table 2.--Mean number (standard error in parentheses) of first- year juveniles counted/minute off the Sonoma coast during August, 1989. Results from other years provided for comparison. n=number of one minute assessments.

Species	1984 n=57	1985 n=50	1986 n=103	1987 n=112	1988 n=62	1989 n=184
S. flavidus	4.39	135.17	6.73	89.39	0.92	1.26
	(1.48)	(26.00)	(2.29)	(18.42)	(7.94)	(0.81)
S. mystinus	4.89	117.63	15.27	328.05	175.06	7.13
	(1.29)	(19.50)	(3.81)	(52.15)	(16.76)	(1.43)
S. melanops	1.63	4.40	3.00	4.48	6.40	2.46
	(0.52)	(1.17)	(1.31)	(1.70)	(1.95)	(0.74)
Total	10.91	257.20	24.97	442.48	221.38	10.85
	(2.12)	(35.38)	(5.17)	(66.72)	(22.55)	

(E. Hobson, FTS 556-0565)

Trends in Sablefish Abundance and Diet with Depth and Time of Day

Sablefish (*Anoplopoma fimbria*) data from 1987 and 1988 SWFC **Jordan** cruises off central California show two trends: 1) changes with depth, and 2) changes with the daily-24 hour cycle. Fishery Biologists Peter Adams and Wayne Samiere of the Groundfish Communities Investigations have identified these basic trends in sablefish population abundance and diet using trawl and stomach contents data. Trawl abundance data (Figure 1) shows an increase in number of sablefish both with increasing depth and during the 0200 to 1000 time strata. Sablefish are not only more abundant with depth, but also have an increasing trend of average size with depth (Figure 2). The low or level abundances of sablefish in

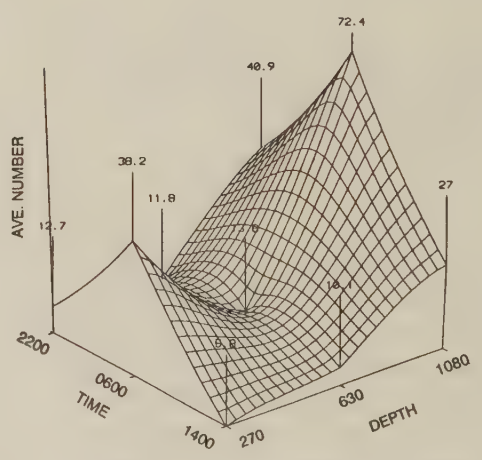

Figure 1. Time and depth distribution (in meters) of sablefish *Anoplopoma fimbria*.

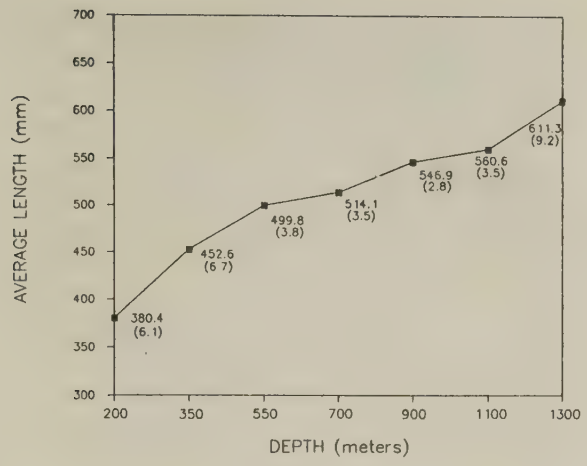

Figure 2. Average length of sablefish *Anoplopoma fimbria* captured during 1987 and 1988 slope survey cruises, by sampling depth.

366-732 m depth strata also occur with the other common fish species. The increase in abundance related to the 0200-1000 time strata occurs in all depth strata, but is less prominent in the 366-732 m strata. The sample size is not large enough to further subdivide the time strata, but there are indications that the increase in the 0200-1000 time strata is occurring just after sunrise (approximately 0600-1000).

Sablefish have two distinct feeding modes; benthic and pelagic. The benthic mode consists of feeding on ophiuroids, polychaetes, and bottom fishes, principally longspine thornyheads, *Sebastolobus altivelis*. The pelagic feeding mode consists of heteropods, thaliaceans, and pelagic fishes such as myctophids, and Pacific whiting. Individual sablefish may be feeding in either or both modes.

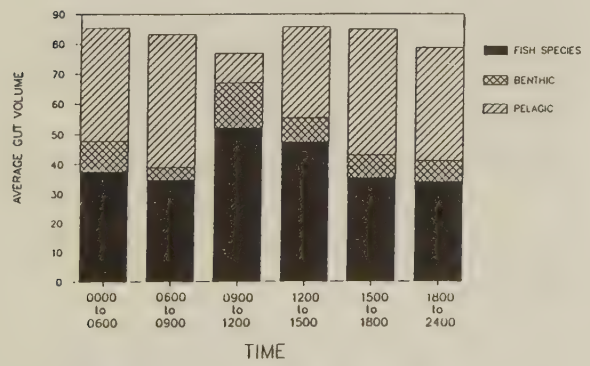

Figure 3. Average gut volumes for major prey groups of sablefish.

Sablefish diet also shows trends with depth and time of day (Figure 3). Fishes increase as part of the diet from 30-50 percent over a depth range of 183-1281 m. The timing of certain prey taken from pelagic habitats shows a strong decline in the diet during morning and mid-day (approximately 0900-1500).

Sablefish have a strong pelagic feeding component. This means that a substantial portion of the population will be off-bottom and unavailable to bottom trawl gear. This has implications for estimating population size, especially since the timing of this off-bottom behavior is not uniform. (P. Adams, FTS 556-0565).

GROUNDFISH PHYSIOLOGICAL ECOLOGY INVESTIGATIONS

Rockfish Conference

Fishery Biologists Drs. Jeannette Whipple and Mickey Eldridge attended a joint Japanese-American conference on reproduction and early life history of rockfishes (Genus *Sebastes*), June 26- July 1, at the University of Hawaii (see p. 6). Eldridge presented a paper entitled "Reproductive performances of yellowtail rockfish, *Sebastes flavidus*" which included much of the research findings from over 3 years of studies on the yellowtail rockfish from Cordell Bank, California. Results that described and analyzed reproductive strategies were organized by multiple levels in an attempt to provide a comprehensive overview of reproductive life history of yellowtail rockfish.

Expansion of Yellowtail Rockfish Sampling

Three years of studies on the reproduction and physiological conditions of yellowtail rockfish from Cordell Bank, California, were recently completed. Preliminary results showed that this population had many traits typical of fish from the southern extent of their range. There were also some unique traits that may relate to their remote seamount habitat. In order to further characterize this population and to relate it to other yellowtail rockfish populations throughout its range, an expanded sampling program is planned that will provide the opportunity to compare the Cordell Bank population with those from Queen Charlotte Sound, the central Washington coast, and Heceta Bank, Oregon. The research is to include synoptic studies that cover such aspects as blood nutrients,

diseases and parasites, gonadal histology, and general measures of condition. Fecundity studies that examine the factors relating to reproductive and adaptive capacities will also be part of this research. The program will begin in November and sampling will be done on both chartered and commercial vessels. (J. Whipple, FTS 556-0565)

GROUNDFISH ANALYSIS INVESTIGATIONS

Widow Rockfish Stock Assessment Draft Prepared

Fishery Biologists Joseph Hightower and William Lenarz of the Groundfish Analysis Investigations prepared a draft of the annual stock assessment report of the widow rockfish fishery. Their assessment utilized catch-at-age data collected from the fishery between 1980 and 1988. Deterministic cohort analysis (computer program GENCOH) and stochastic catch at age analysis (computer program Cagean and the stock synthesis model of Methot) were used to analyze the data.

The deterministic and stochastic approaches have different strengths and weaknesses. The deterministic approach assumes that catches-at-age are measured without error, which is unlikely, and it is necessary to provide starting values of fishing mortality. However the deterministic approach allows age specific selectivity to vary from year to year. The stochastic approaches do not allow age specific selectivity to vary from year to year and also require some constraints on starting values of fishing mortality. However the stochastic approaches fit fewer parameters and allow catch-at-age to be measured with error. The stock synthesis model allows age specific selectivity curves to vary from area to area. This feature was explored for three separate areas. While the results were promising, the practical use of area specific selectivity curves awaits further work.

While there is some uncertainty in the strength of recent year-classes and current biomass, results of the assessment indicate that biomass is lower than in previous years and that the harvest should be reduced. The lower biomass is the result of the normal fishing down process and the entry of two very weak year-classes into the fishery. The biomass is estimated to be close to the maximum sustainable yield level. The authors recommend that the 1990 harvest be set at 7,900 t. This is lower than the expected 1989 harvest, 12,400 t, and the 1984-88 average, 10,000 t.

The report will serve as the technical basis for the recommendation of allowable biological catch (ABC) by the Groundfish Management Team to the Pacific Fishery Management Council after review. The review process began in Tiburon, August 7-9, when Hightower and Lenarz presented the report to the Ad Hoc Stock Assessment Committee of the team. Hightower also presented this assessment to the team later in the week. The report has been distributed to the Scientific and Statistical Committee of the Council for further review. The team will make its recommendation for ABC during the November Council meeting. (J. Hightower, FTS 556-0565)

INFORMATION TECHNOLOGY SERVICES

Inspector General Reviews Information Technology 1995 Project

A special unit of the Commerce Inspector General's (IG) office has been reviewing future high-tech procurements, including major computer systems within NMFS. Two of their specialists were appointed to survey the NMFS Information Technology (IT) project, and have been gathering information about regional computer resources, planning processes for the proposed NMFS-wide IT-95 computer system, and the Request for Proposal for the system. Dorothy Roll, Computer Systems Analyst, has been assisting the Washington office in these interactions with the IG. A report on the investigation was released by the IG in August, in which the suitability of the IT-95 system project was questioned. NMFS and the IG office are now negotiating the issue, and until further notice, action on the IT-95 project is on hold. (D. Roll, FTS 893-7057)

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Published

Butler, John L., Carol A. Kimbrell, William C. Flerx and Richard D. Methot. 1989. The 1987-88 demersal fish surveys off central California (34°30'N to 36°30'N). U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFC-133, 11 p.

Mason, Janet E. 1989. The southern California jack mackerel fishery, and the age and length composition of the catch for the 1972-73 through 1983-84 seasons. Calif. Dep. Fish and Game, Mar. Res. Tech. Rep. 58, 38 p.

Moffitt, Robert B., Frank A. Parrish and Jeffrey J. Polovina. 1989. Community structure, biomass and productivity of deepwater artificial reefs in Hawaii. Bull. Mar. Sci. 44:616-630.

Artificial reef modules constructed of plastic or concrete were deployed at three sites in deep water on Penguin Bank, Hawaii, in October 1985. Fish communities were censused shortly after deployment and irregularly thereafter, by using the manned submersibles *Makalii* and *Pisces V*. In determining the aggregated biomass of transient fish species, depth of reef placement was more important than the reef's structural material and configuration. Conversely, reef structural material and configuration were more important than depth in determining the species diversity, richness and perhaps biomass of resident species attracted to these deepwater artificial reefs. Results suggest that small-scale, deepwater artificial reefs in Pacific island areas function primarily as devices for aggregating fish rather than increasing fish production and that reef configuration and structural material are not very important in aggregating transient species.

Polovina, Jeffrey J. 1989. A debate on responsible artificial reef development. Part III. Should anyone build reefs? Bull. Mar. Sci. 44:1056-1057 (Note).

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The role of artificial reefs as a tool for increasing fishery production rather than just aggregating fish is addressed for two fisheries, octopus, *Octopus dofleini*, and flatfish, (Pleuronectidae), near Shimamaki, Japan. The time series of catch and effort data examined covers periods before and after two adjacent fishing grounds received 8,645 and 40,766 m^3 of artificial reef. Octopus catches were increased by 4% per 1,000 m^3 of artificial reef or by an average of 1.8 kg/m^3 of artificial reef. Artificial reefs aggregated flatfishes but did not increase catches in the regions. A survey of fishermen in the two regions revealed that the reefs generally are considered beneficial.

Ralston, Stephen and Happy A. Williams. 1989. Numerical integration of daily growth increments: An efficient means of ageing tropical fishes for stock assessment. Fish. Bull., U.S. 87:1-16.

For an objective, cost-effective ageing methodology applicable to tropical species, a new approach to estimating parameters of the von Bertalanffy growth equation through the study of otolith microstructure was developed and applied to *Pristipomoides zonatus*, a deepwater snapper widely distributed throughout the Indo-Pacific region. The average width of sagittal daily growth increments was used to measure otolith growth rate, which was then related to the size of the otolith. The data were numerically integrated, providing estimates of age (in years) at regular 500-μm increments to otolith length, which was then used to predict fork length (FL mm) at age with regression analysis. The data were fitted to the von Bertalanffy growth model, resulting in

$$FL=442\ (1-\exp(-0.234(Age+0.892))).$$

The method was critically examined and validated through the study of 1) annual hyaline and opaque markings that appear in the otoliths, 2) Monte Carlo simulation, 3) length-frequency analysis, 4) examination of spawning seasonality relative to back-calculated birth date taken from the time of first annulus formation, and 5) empirical comparisons with the literature concerning snapper growth.

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